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are supposed to be equal to four corresponding increments of depth of shade, the numerical ratios being *direct*, instead of *inverse*, as in Smyth's scale. And it is at once apparent how readily these terms admit of reduction in discussing a number of observations. I have not thought it necessary to specify the subordinate colours here, as their corresponding symbols appear on the diagram. But though they all follow the same invariable rule—that is, the *inner* circle means *white tinged* with the given colour: circle 2, a *pale* tint of the colour; circle 3, the *normal* colour; and circle 4, the *deepest* tint of colour, yet it will not, in all probability, be requisite to use the first term in their series, as six different tints of white are as many as can be well distinguished from each other.

P.S.—The original diagram, of which the annexed is a copy, was executed in water-colours, and gives a much better idea of the proposed scheme than one in black and white can possibly do, but it would probably be difficult and expensive to reproduce in a satisfactory manner.

On the Best Device for Revolving a Dome. By Professor David P. Todd.

(*Communicated by the Secretaries.*)

The various methods which have been devised for applying power to revolve a dome show that it is a matter of considerable importance in observatory construction. The number of these methods shows also that many of them, at least, are imperfect either in principle or construction. A very common method, especially in the older observatories, consists of a continuous rachet or cog-wheel run around the bed-plate or interior of the dome, in which a cog-wheel on a short journal runs, the power being communicated to this latter in the simplest manner. The difficulties in the way of this device consist rather in the imperfection of the running-gear of the dome itself. In constructing the large dome of the Washburn Observatory, at Madison, Wisconsin, the late Professor Watson sought to overcome these difficulties by a double cog-wheel, which should work into the rachet of the dome on exactly opposite sides of the latter. In order to secure this end, a somewhat cumbersome apparatus was devised and applied, consisting of two vertical shafts on opposite sides of the dome geared into a rigid horizontal shaft, running across from one side to the other, underneath the floor of the dome. This apparatus is described in Vol. I. of the publications of this Observatory. In constructing the smaller dome of the Lick Observatory, the idea occurred to Mr. Fraser, the superintendent of construction, that the dome itself might be considered as a large pulley, and a rope run around it as such, and brought into the inside of the dome, where it was carried around a suitable

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FIG. 1.

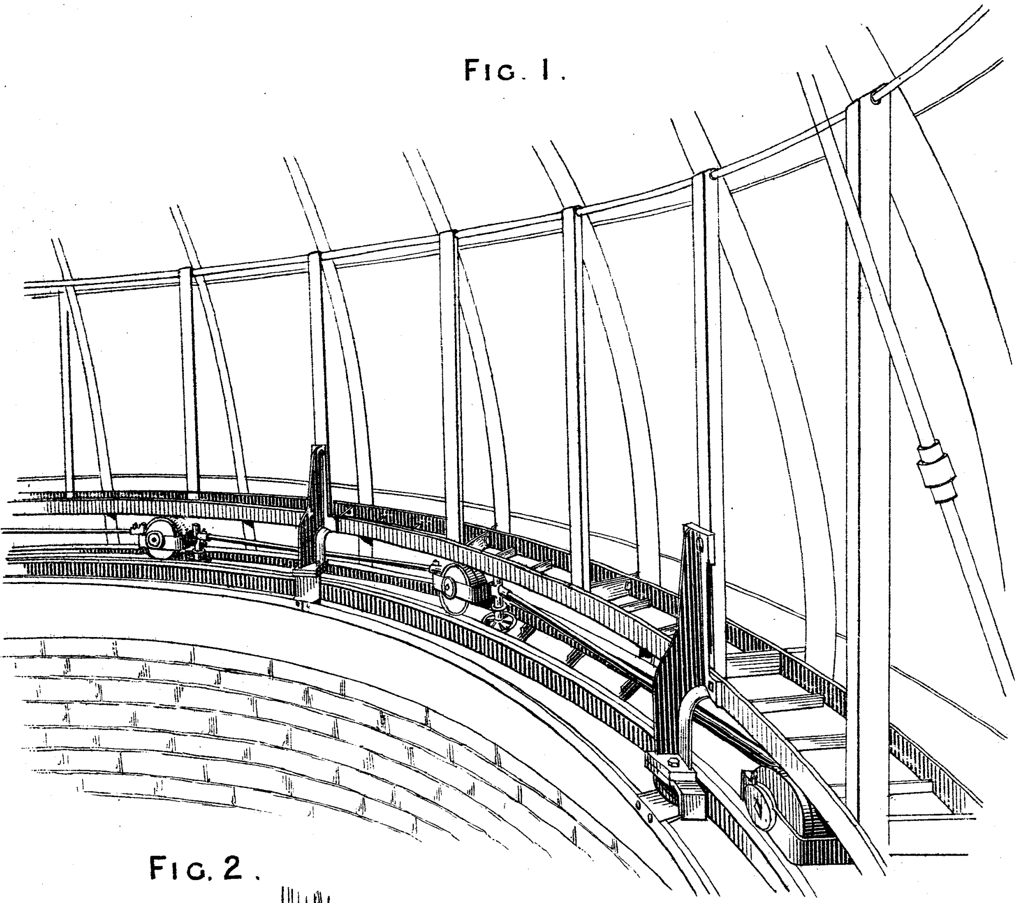


FIG. 2.

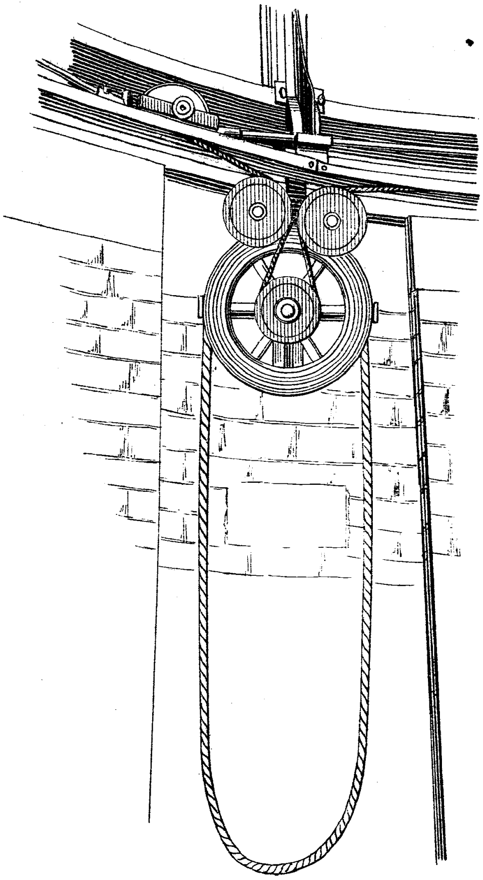
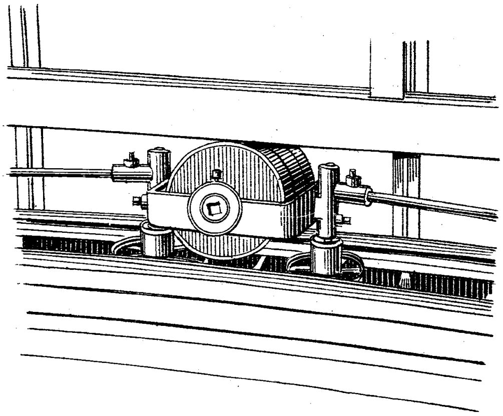


FIG 3.



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pulley connected with the gearing and a crank. This device works in the most perfect manner, and there is no objection to it except that, the rope being run around the outside of the dome, it is not easy to secure perfect weather protection at the point where the rope passes to the inside of the dome. In addition to this, the rope itself where exposed on the exterior of the dome would require protection from the weather, especially in our northern latitudes.

When Mr. Warner, of the firm of Warner and Swasey, of Cleveland, was at the Lick Observatory in May last, the idea occurred to him that the wire rope employed in turning the dome could, by means of a suitable device, be run around the inside of the dome quite as well as the outside, thus rendering special weather protection unnecessary, and reducing the apparatus to a very compact form. The accompanying plate (figs. 1–3) gives a good idea of this new device as constructed by Mr. Warner for the first time, and applied to the 22-feet dome of the new observatory at Smith College, Northampton. It will be seen that there are attached to the projecting uprights of the dome a series of horizontal grooved pieces, curved to the same radius as that of the dome itself. These pieces form a continuous grooved pulley on the inside of the dome, and concentric with it. Immediately underneath the bed-plate of the dome, and rigidly attached to the wall, is a framework carrying the pulleys as represented in the plate (fig. 2). Around the largest of these pulleys passes an inch rope, to which the necessary power is applied by the hand. On the same axle with this large pulley is a small pulley, around which a wire cable passes which revolves the dome directly. To facilitate the running of the wire rope from this small pulley into the large grooved pulley of the dome itself, a pair of idle pulleys are placed immediately underneath the grooved pulley attached to the dome. As these loose pulleys are placed very near together, they serve also the purpose of giving the rope a larger bearing service upon the motor-pulley below them. It will be seen that the device is a very simple and compact one. It is all contained in a shallow niche in the wall, and is thus entirely beyond the reach of the observing-chair as it moves upon the floor of the dome. The distribution of the power to every part of the circumference of the dome by means of the wire rope is an important advantage not secured in any form of cog-wheel apparatus. The bearing surface of the wire rope upon the dome is nearly 70 feet long; so that, although the rope may be quite loose, there is still friction enough to move the dome readily. The perfection of the running-gear of the dome itself has, of course, much to do with the ease of movement of this revolving apparatus. In the case of the dome alluded to above, a three-pound weight is sufficient to set the dome in motion, the ratio of descent of the weight to the movement of the periphery of the dome itself being about as three to one.

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In connection with the accompanying illustration of a section of the running-gear of the dome, the following brief description will make its construction clear. First, being assured that the tracks on the wall-plate and the conical wheels are turned to their exact cones, the next important point is to hold these wheels so that their axes produced will converge to a point at the centre of the tracks. Messrs. Warner and Swasey have found it impossible to accomplish this by any system of bearing of the live ring. They therefore provide a yoke for each conical wheel. In addition to carrying the journals of the conical wheel, each yoke carries also two guide-wheels, which run between the tracks of the wall-plate. These guide-wheels are so adjusted as to keep the axis of the conical wheel coincident with the true radius of the circle of the wall-plate. These guide-wheels obviate also the necessity of flanges on the conical wheels, while the yokes merely require connection with each other by single flexible rods, forming thus the continuous live ring. By these simple devices the friction is so largely reduced that the dome may be readily revolved by the application of a direct tangential pressure of $1\frac{1}{2}$ pound for each ton's weight.

A Centering Tube for Reflecting Telescopes. By Edward Crossley.

To facilitate the centering of the "Common" 3-foot Reflector I have constructed a tube with diaphragms, by means of which the mirrors can be adjusted with the greatest ease.

The tube I use is 10 inches long and $2\frac{5}{8}$ inches in diameter. This is placed in the eye end at the side of the telescope. The end of the tube towards the eye has a small pin-hole. The othe end towards the mirrors has two diaphragms which will replac each other concentrically. The large diaphragm is 1·96 inch in diameter, the small one is 0·37 in diameter. The large diaphragm just embraces the large mirror, which can be centered b means of the flat. The small diaphragm is then put in its place, and the flat centered by means of the adjustment of the larg mirror, or, better still, by the adjustment of the eye end.

Thus the telescope can be centered in any position wit accuracy during the day or with illumination at night.

The sizes of the diaphragms are proportionate to the diameter of the large and small mirrors respectively, and the length of th tube is a little less in proportion than the focal length so as t embrace a rather larger angle.

At night time a reflector is necessary within the tube at a angle of 45° to the tube, with an opening at the side so as t throw the light of a lamp held in the hand upon the inner fac of the diaphragm, and a white sheet of paper stretched on hoop can be set in front of the telescope and illuminated b another lamp. This, however, is not necessary if the work i properly done in the daytime.